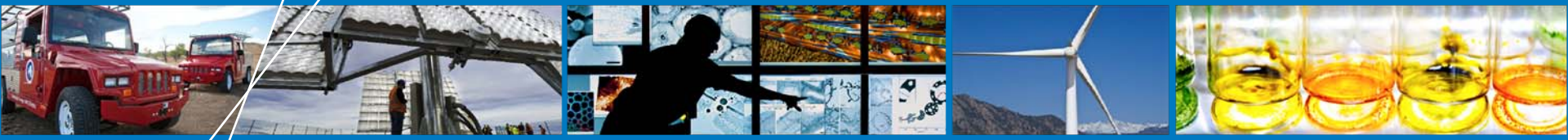
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Station Costs in the Joint AB8 Report



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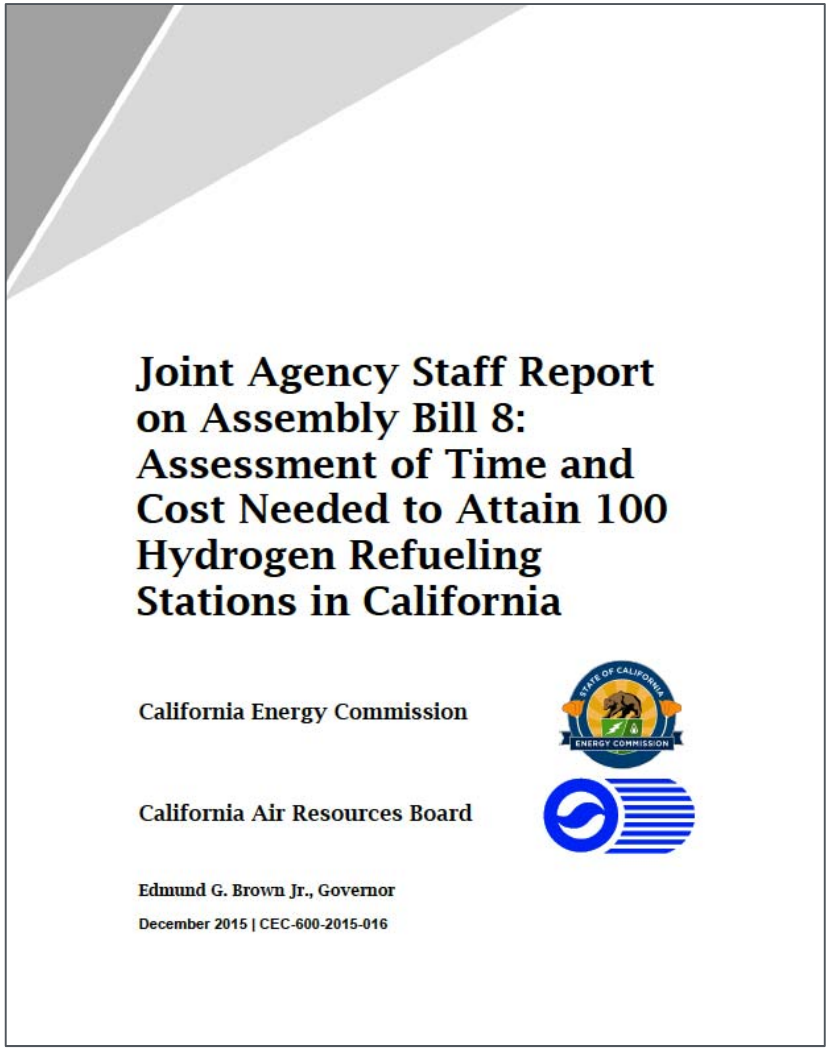
NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

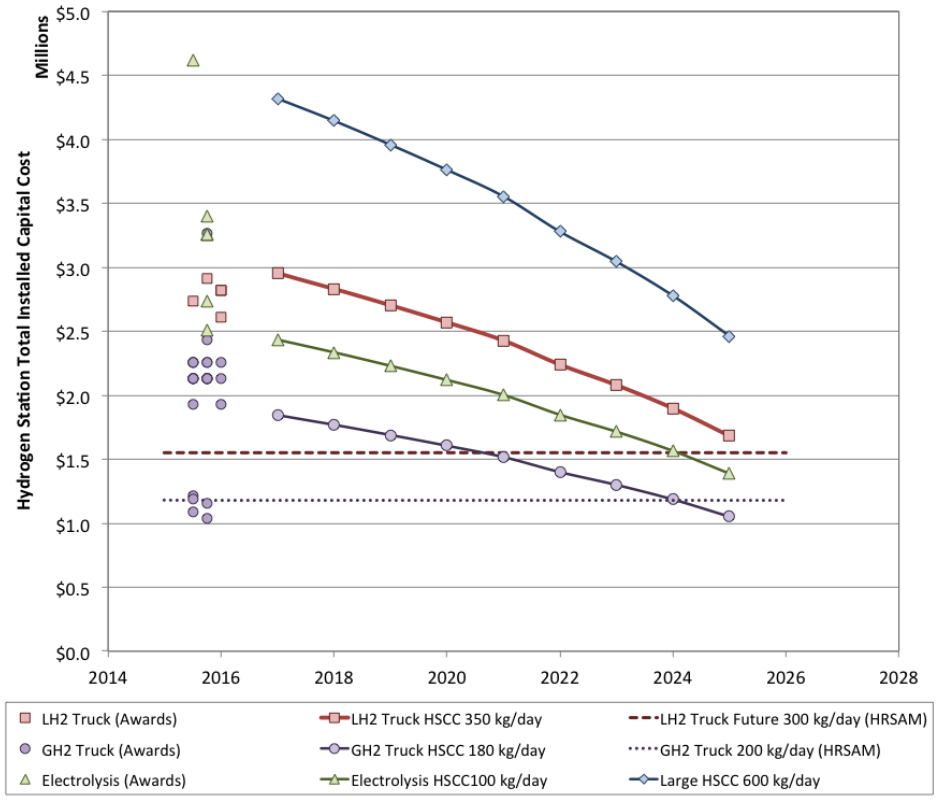
Presentation Overview

- Station cost trends in the AB8 Report
- Retail price margin and "delivered" cost of H2
- Cost of renewable hydrogen
- Issues related to cost and price trends



Station Cost Trends

- Capital costs decline with (global) capacity
- Costs have been empirically grounded to the degree possible
- Quality of cost trend data is expected to improve over time
- Higher resolution data will allow for targeted reduction strategies



APPENDIX B:
Station Costs

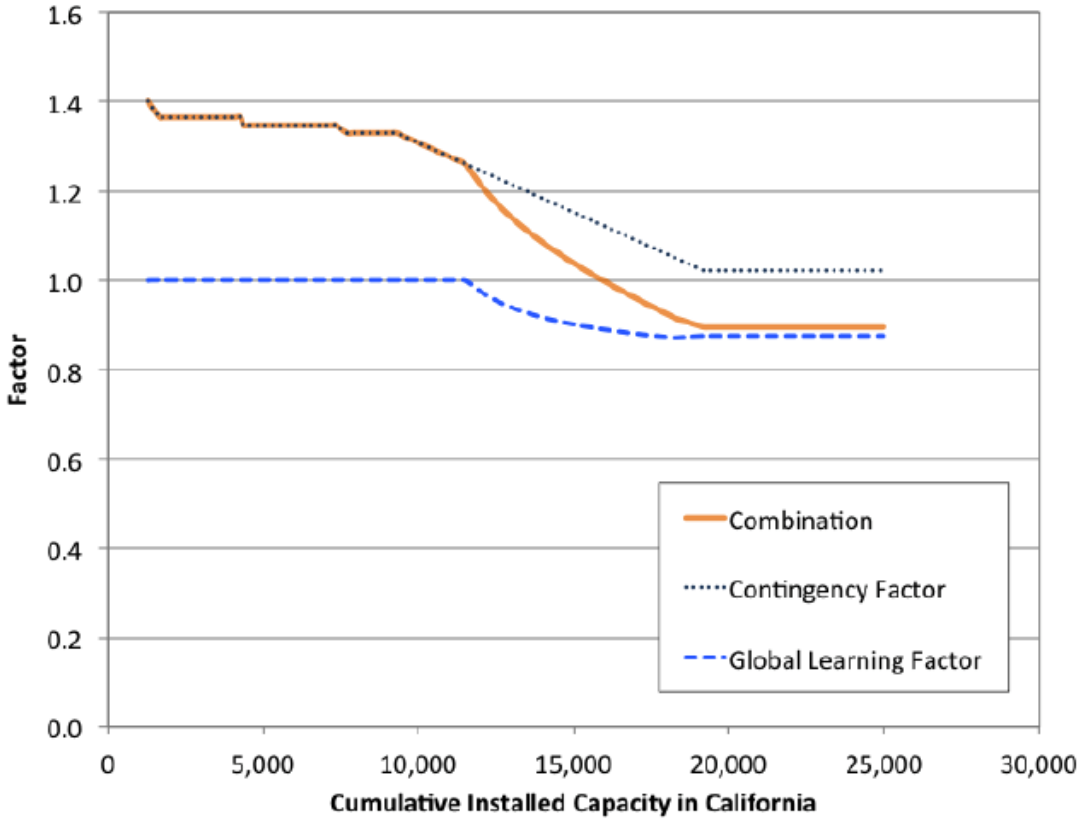
Stn #	Name	County	Capacity (kg/day)	Total Capital ($1000s)	Incentive ($1000s)		Station Type
					Capital	Operating	
1	Coalinga- W Dorris	Fresno	180	$2,055	$1,451		GH2 Truck
2	San Ramon- Bishop	Contra Costa	350	$2,783	$2,125		GH2 Truck
3	Burbank- W Verdguo	Los Angeles	100	$1,800	$940	$0.300	SMR
4	Irvine - Jamboree	Orange	30	$2,451	$1,960		GH2 Truck
5	Torrance- W 190th	Los Angeles	60	$3,095	$2,476		Pipeline
6	Newport Beach- Jamboree	Orange	100	$1,037	$829		GH2 Truck
7	Harbor City- S. Western	Los Angeles	60	$2,500	$0	$0.300	Electrolysis
8	Los Angeles- State University	Los Angeles	60	$984	$0	$0.300	Electrolysis
9	Diamond Bar- E Copley	Los Angeles	180	$2,933	$1,467	$0.300	Electrolysis
10	Los Angeles- Aviation	Los Angeles	100	$3,288	$2,630		SMR
11	Los Angeles- Santa Monica	Los Angeles	180	$2,496	$1,997		GH2 Truck
12	Chino- East End	San Bernardino	100	$4,558	$3,000		Electrolysis
13	Los Angeles- Beverly	Los Angeles	180	$8,364	$6,691		GH2 Truck
14	Los Angeles- Cloverfield	Los Angeles	180	$984	$2,046		GH2 Truck
15	Redondo Beach- Beryl	Los Angeles	180	$2,521	$2,017		GH2 Truck
16	South Pasadena- Fair Oaks	Los Angeles	180	$2,055	$1,451		GH2 Truck
17	Woodland Hills- Topanga Canyon	Los Angeles	180	$3,358	$2,686		GH2 Truck
18	Anaheim- E La Palma	Orange	100	$2,434	$1,500		GH2 Truck
19	Costa Mesa- Harbor	Orange	180	$2,055	$1,451		GH2 Truck
20	Irvine- Walnut	Orange	180	$2,543	$2,034		GH2 Truck
21	La Cañada-Flintridge- Foothill	Los Angeles	180	$2,055	$1,451		GH2 Truck
22	Lawndale- Inglewood	Los Angeles	180	$2,497	$1,998		GH2 Truck
23	Los Angeles- Lincoln	Los Angeles	180	$2,055	$1,451		GH2 Truck
24	Los Angeles- Hollywood	Los Angeles	180	$2,055	$1,451		GH2 Truck
25	Ontario- Holt	San Bernardino	100	$3,459	$3,097		Electrolysis
26	Orange- East Chapman	Orange	130	$3,255	$1,769		Electrolysis
27	Pacific Palisades-Pac. Coast Hwy	Los Angeles	130	$3,255	$1,769		Electrolysis
28	Long Beach- Long Beach	Los Angeles	180	$2,055	$1,451		GH2 Truck
29	Lake Forest- Lake Forest	Orange	180	$2,531	$1,451	$0.300	GH2 Truck
30	San Juan Cap.- Junipero Sera	Orange	350	$2,732	$2,732		LH2 Truck
31	Laguna Niguel- Crown Valley	Orange	180	$2,055	$1,451		GH2 Truck
32	Mission Viejo- Marguerite	Orange	180	$2,687	$1,500		GH2 Truck
33	Riverside- Lincoln	Riverside	100	$3,587	$2,125		Electrolysis
34	West Sacramento- South River	Yolo	350	$2,495	$2,495	$0.300	LH2 Truck
35	San Diego- Carmel Valley	San Diego	180	$2,055	$1,451		GH2 Truck
36	Mill Valley- Redwood	Marin	180	$2,055	$1,451		GH2 Truck
37	South San Francisco- S Airport	San Mateo	180	$2,055	$1,451		GH2 Truck
38	Hayward- West A	Alameda	180	$2,055	$1,451		GH2 Truck
39	Palo Alto- El Camino Real	Santa Clara	180	$3,209	$2,125		GH2 Truck
40	Woodside- Skyline	San Mateo	140	$3,253	$2,125		Electrolysis
41	Foster City- Foster City	San Mateo	350	$2,505	$1,500		LH2 Truck
42	Oakland- Langley	Alameda	350	$2,566	$2,125		LH2 Truck
43	Redwood City- Veterans	San Mateo	180	$2,055	$1,451		GH2 Truck
44	Campbell- Winchester	Santa Clara	180	$2,055	$1,451		GH2 Truck
45	Saratoga- Saratoga	Santa Clara	180	$2,055	$1,451		GH2 Truck
46	San Jose- North First	Santa Clara	180	$2,055	$1,451		GH2 Truck
47	Los Altos- Homestead	Santa Clara	350	$2,532	$1,500		LH2 Truck
48	Mountain View- Leong	Santa Clara	350	$2,532	$1,500		LH2 Truck
49	Santa Barbara- S La Cumbre	Santa Barbara	180	$2,055	$1,451		GH2 Truck
50	Rohnert Park- Redwood	Sonoma	130	$3,255	$1,769		Electrolysis
51	Truckee- Donner Pass	Nevada	180	$2,055	$1,451		GH2 Truck

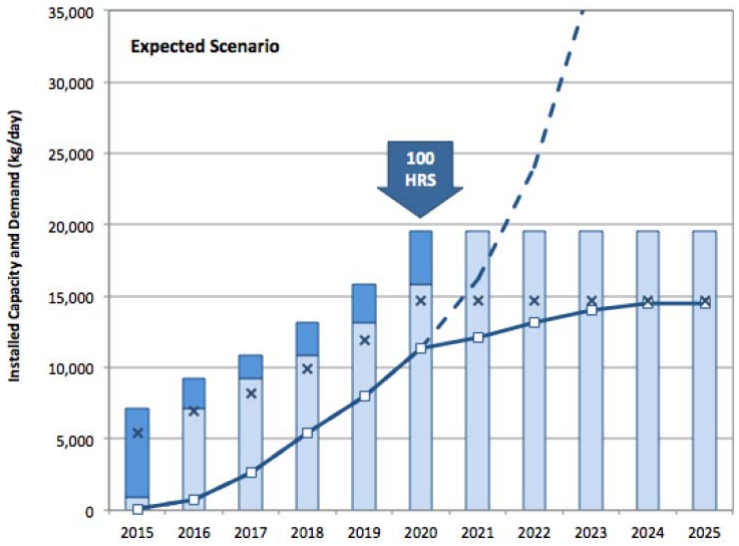
Source: California Energy Commission

Contingency Factor & Learning function

- Given high variability of cost data collected to date, a relatively conservative contingency factor was assumed
- Assumed global station plans move forward (dotted blue line)

Figure C-1: Contingency and Global Learning Factors for Capital Costs

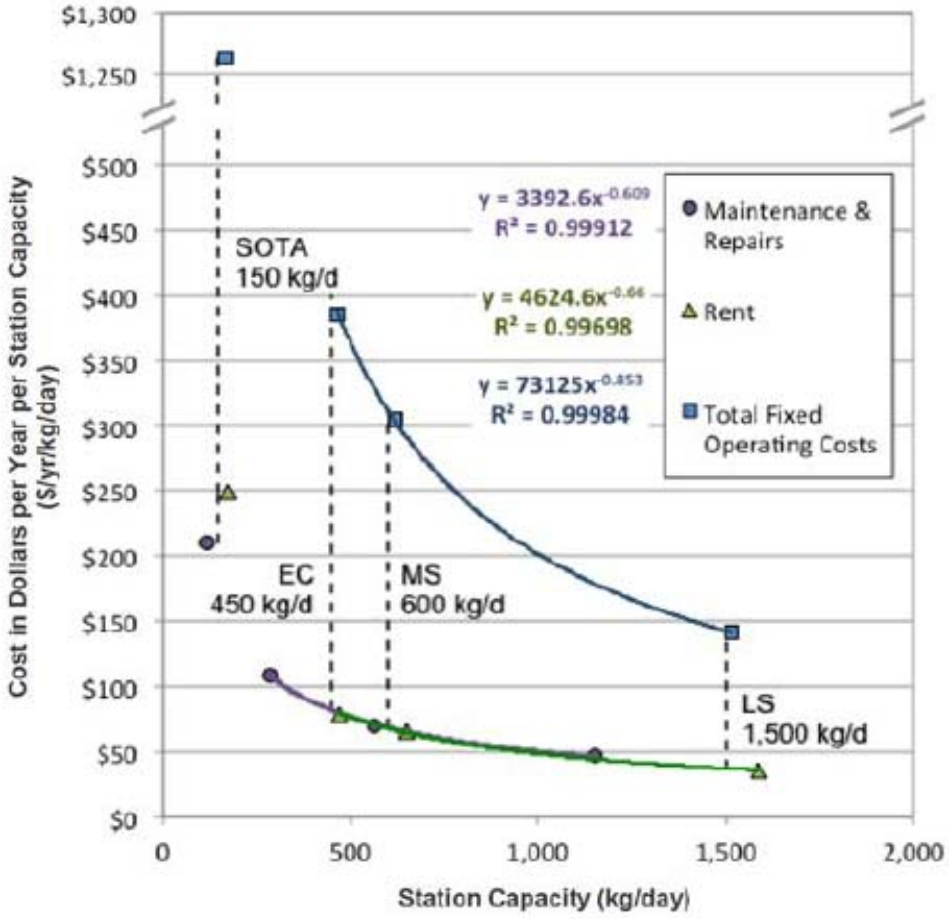




Both factors are resolved by 20,000 kg/day around 2020

Operating costs

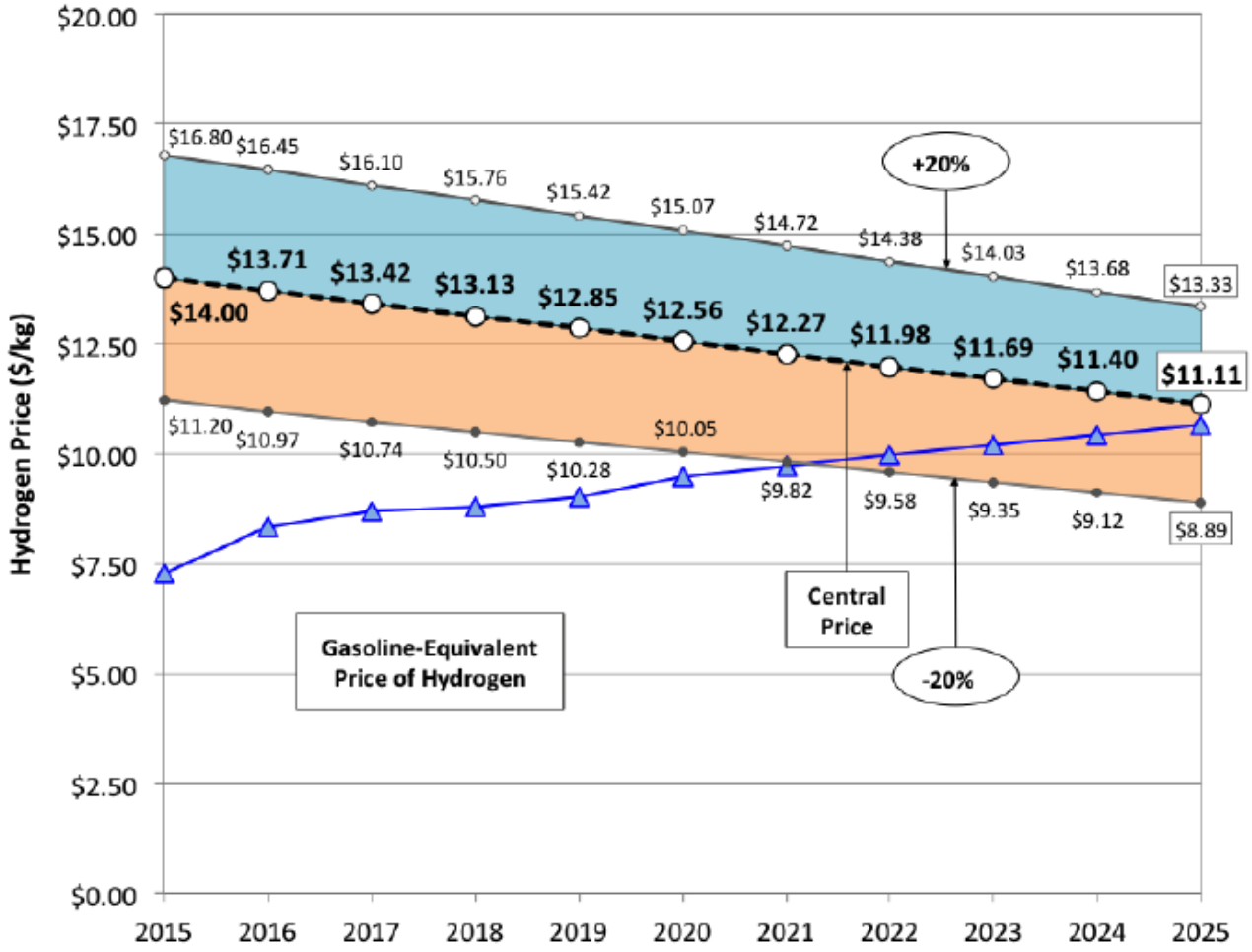
- **Without more detailed empirical data on operating costs, a survey-based cost function was assumed (NREL HSCC study)**
- **Additional real-world data will improve this input over time.**



A data exchange process with CEC-NREL is in place. Updated data will be used each year.

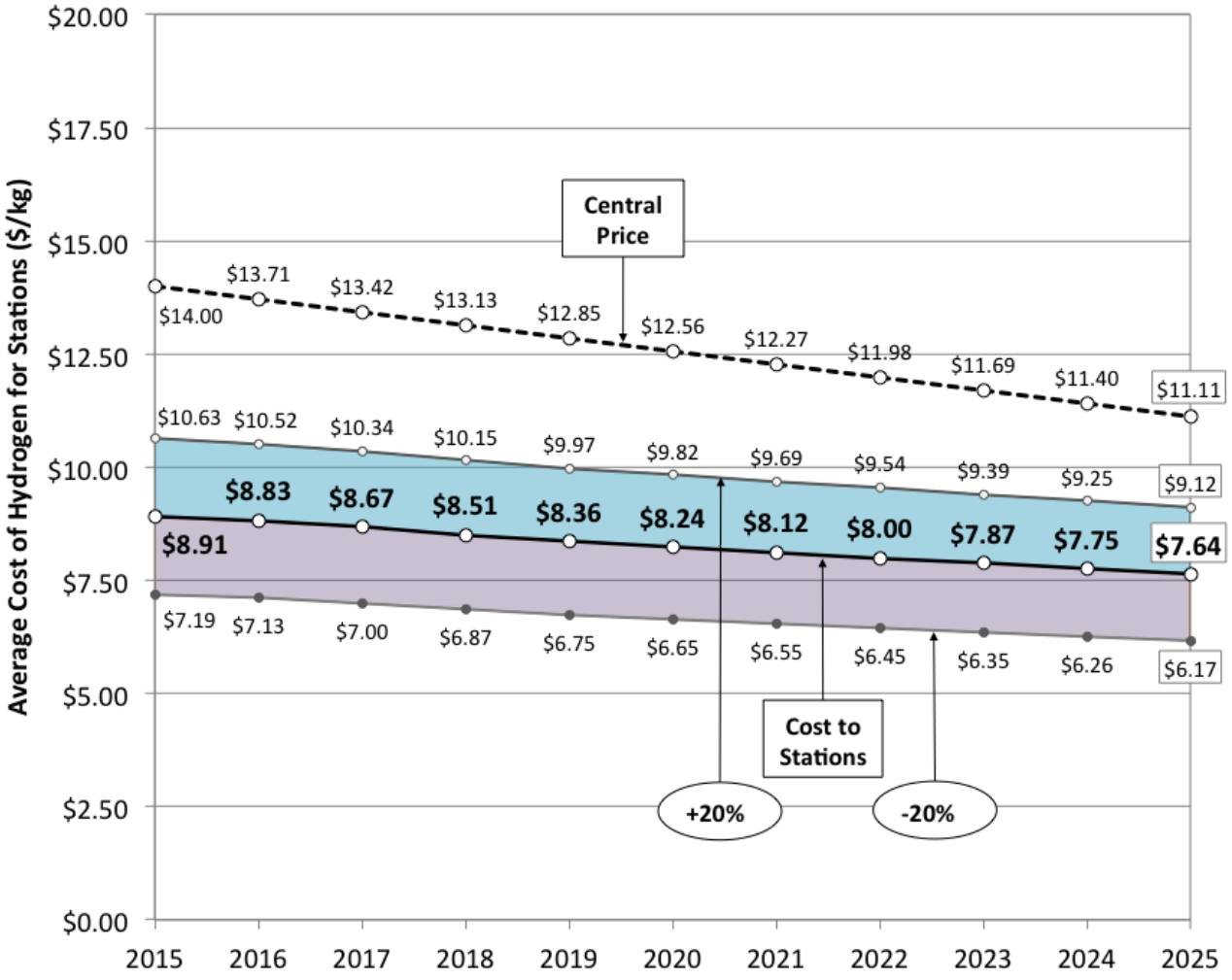
Modeling Input: Price of hydrogen over time

Starting with 2015 price of $14/kg and dropping linear to gasoline-equivalent price by 2025 ($11.11/kg). Sensitivity bands of 20%.

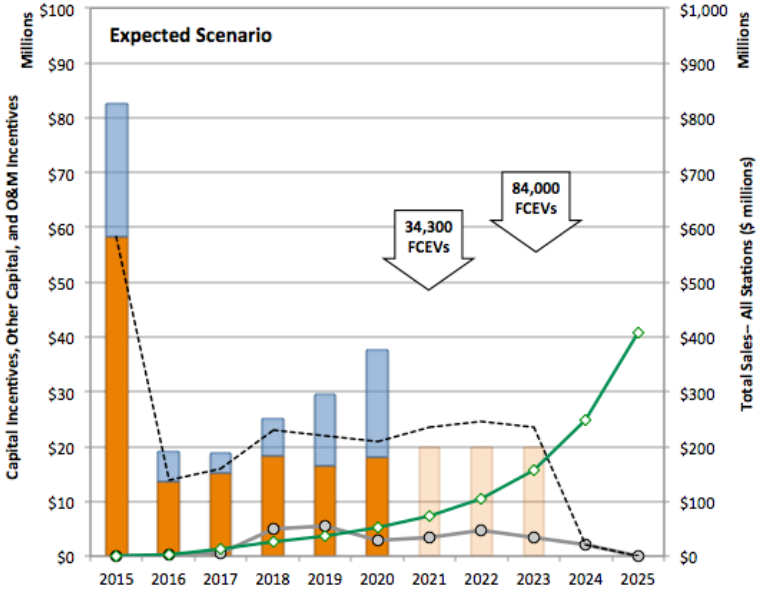


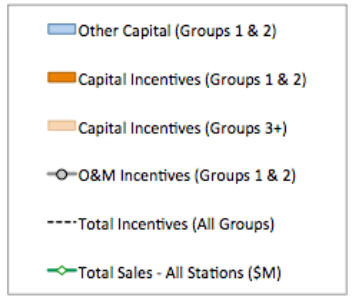
Spread between cost to station and price to FCEVs

All stations must be covered by revenue represented by this spread (Station Revenue = Price – Cost)

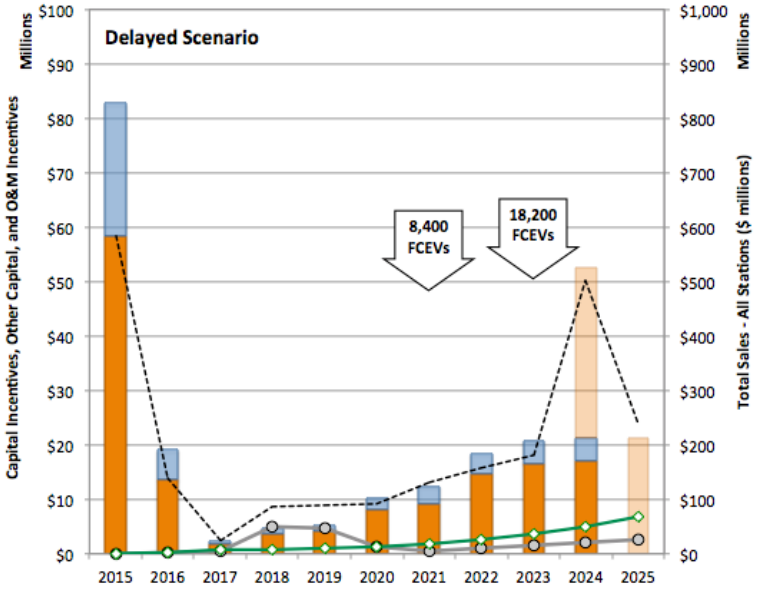


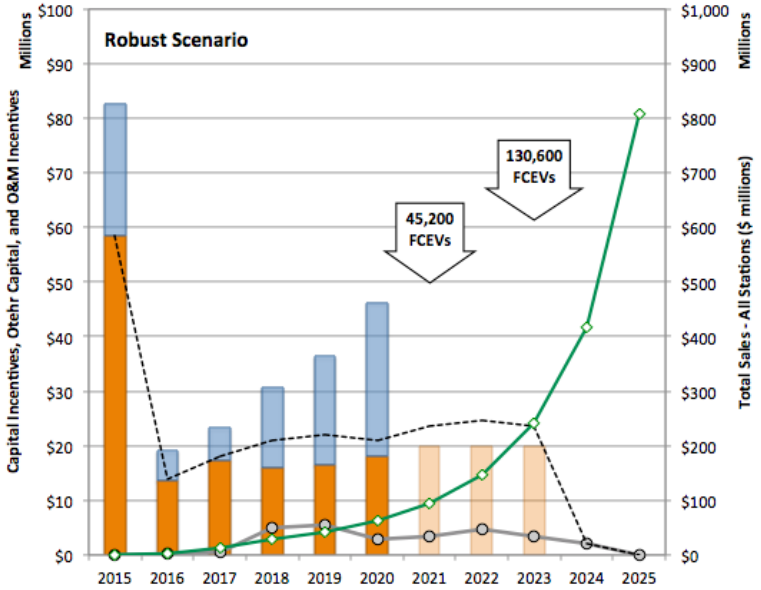
Network results are aggregate of all HRS



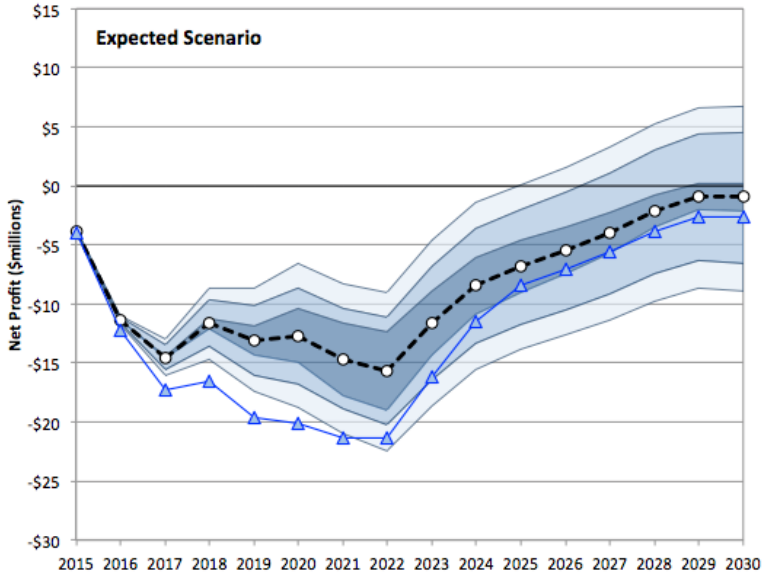


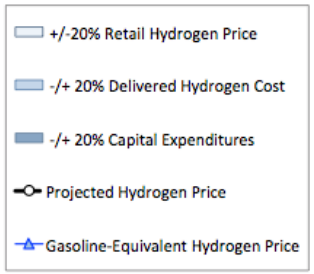
NOTES
- The values shown are for years in which stations are installed, with funds having been awarded and other capital having been invested in earlier years.
- Revenues from Total Hydrogen Sales for all stations are shown with units on the right-hand vertical axis, which is 10 times larger in scale than the left-hand vertical axis. Arrow labels indicate the number of FCEVs on the road in 2021 and 2023.
- Compared to the Expected scenario, the Robust scenario awards more funds to stations installed in 2017 and leverages more private capital with stations installed in 2018-2020.
- In the Delayed scenario capital incentives are modulated in response to slower demand growth. With 100 HRS established in 2024, remaining funds are allocated to Group 3+ stations installed in years 2024 and 2025.



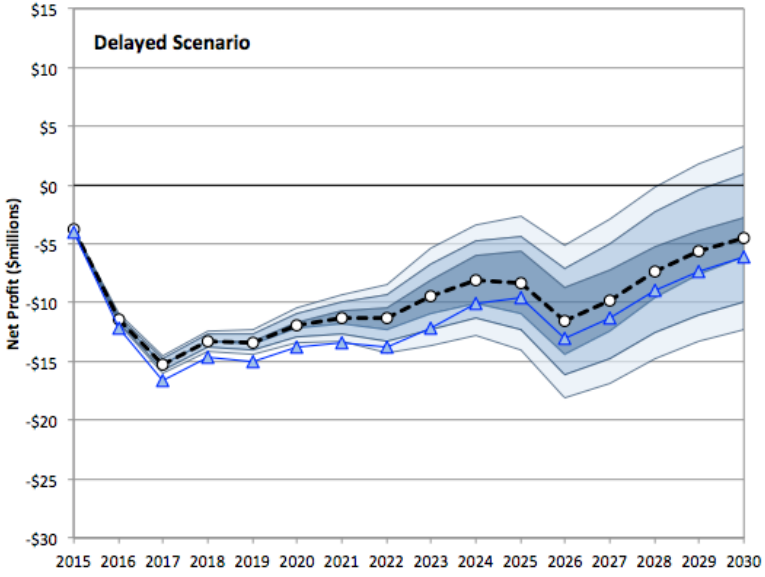


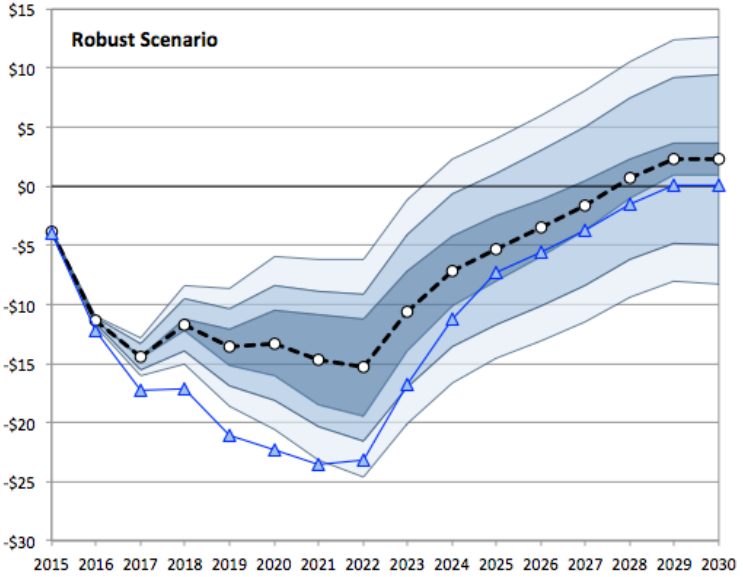
Net Profit: Total revenue after all expenses





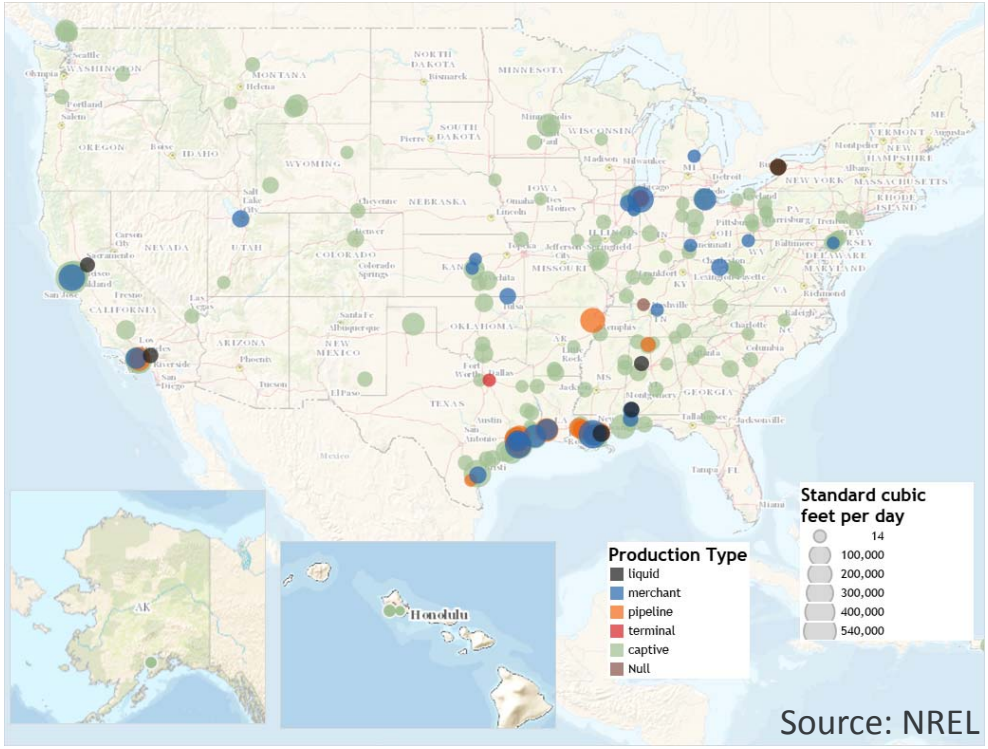
NOTES
- For the central hydrogen price case, Net Profit is negative for each scenario for most of the analysis period, only becoming positive for the Robust scenario in 2028. However, the trend is upwards for each scenario following a low of about negative $15 million in 2022 in the Expected and Robust scenarios, and negative $13 million in 2026 in the Delayed scenario.
- For the -20% delivered hydrogen sensitivity, each scenario does achieve positive net profit before 2030.



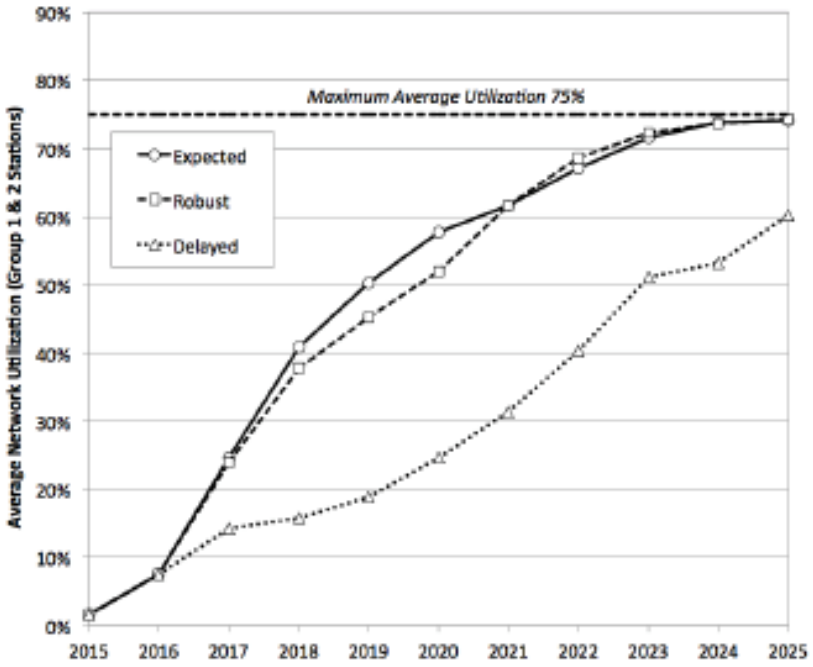


Key Factors: Delivered cost, utilization, HRS size

- **An improved bottom-up estimates of delivered hydrogen is needed.** This should include options for renewable hydrogen.
- **Many renewable production systems must be at large scale to achieve low costs (e.g., central wind electrolysis or biomass gasification).**
- **Larger capacity stations needed to reduce retail costs (local pipelines?).**



Source: NREL



Issues Related to Costs and Prices

1. **Statewide finance metrics represent the entire HRS network**
2. **Station-specific costs and financing will vary significantly, especially due to equipment costs and changes in utilization**
   a. Incumbent stations will tend to be at a disadvantage compare to new, larger-capacity market entrants
   b. ARFVTP grants shield early stations to some degree, but other measures may be needed to improve robustness of individual business cases and overall network (e.g. franchise territories, service charge for connector stations, etc.)
3. **Some stations may not have a positive financial performance *on their own*, but each station adds value to the *overall network***
4. **Overall network cost reductions (average $/kg) can only be achieved with installation and high utilization of larger stations**
   a. This trend may be at odds with legacy stations remaining robust.
   b. Some small stations will always be needed due to geography.

Questions?

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